BTeV Pixel Detector Overview

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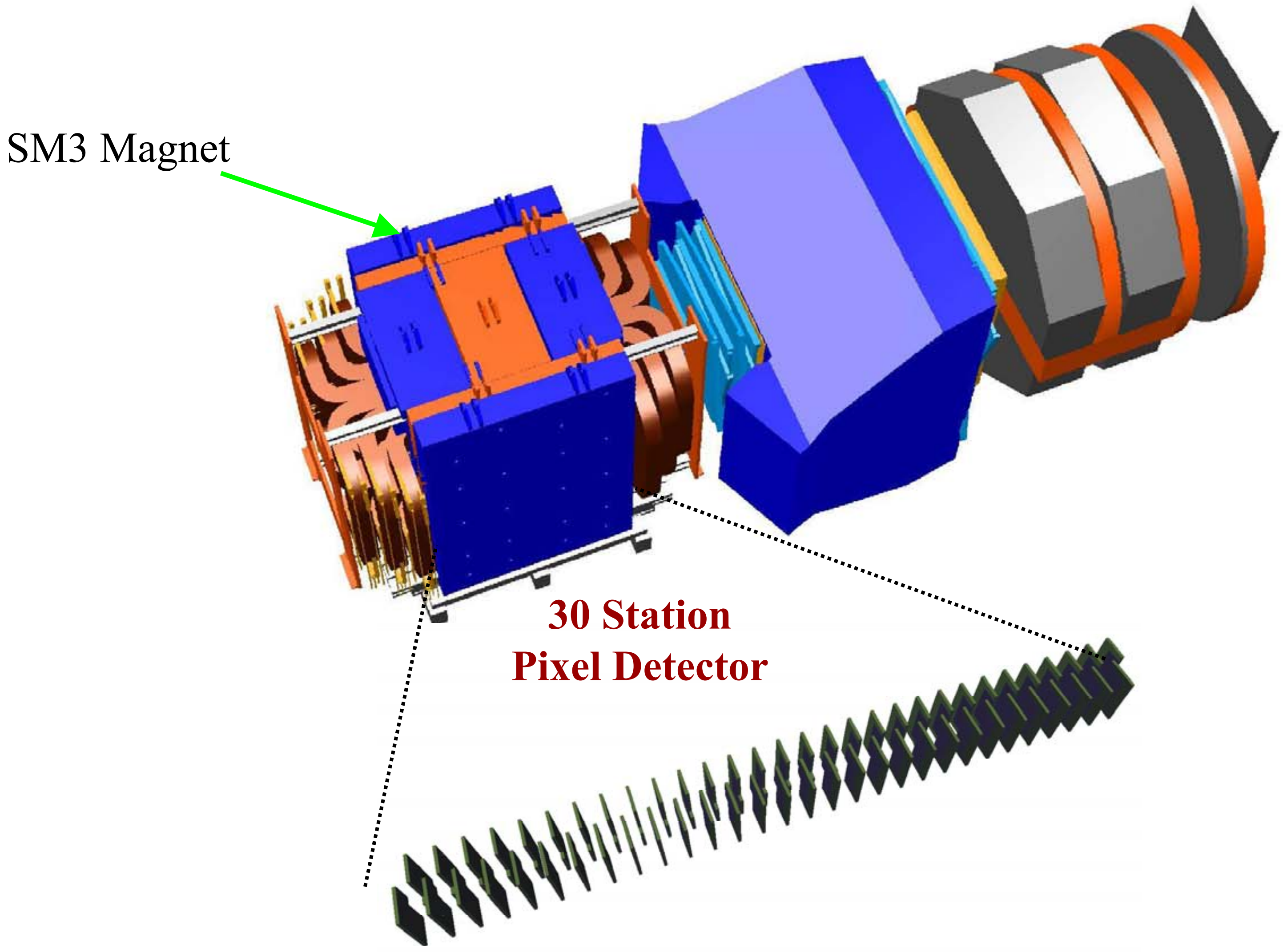
BTeV Detector



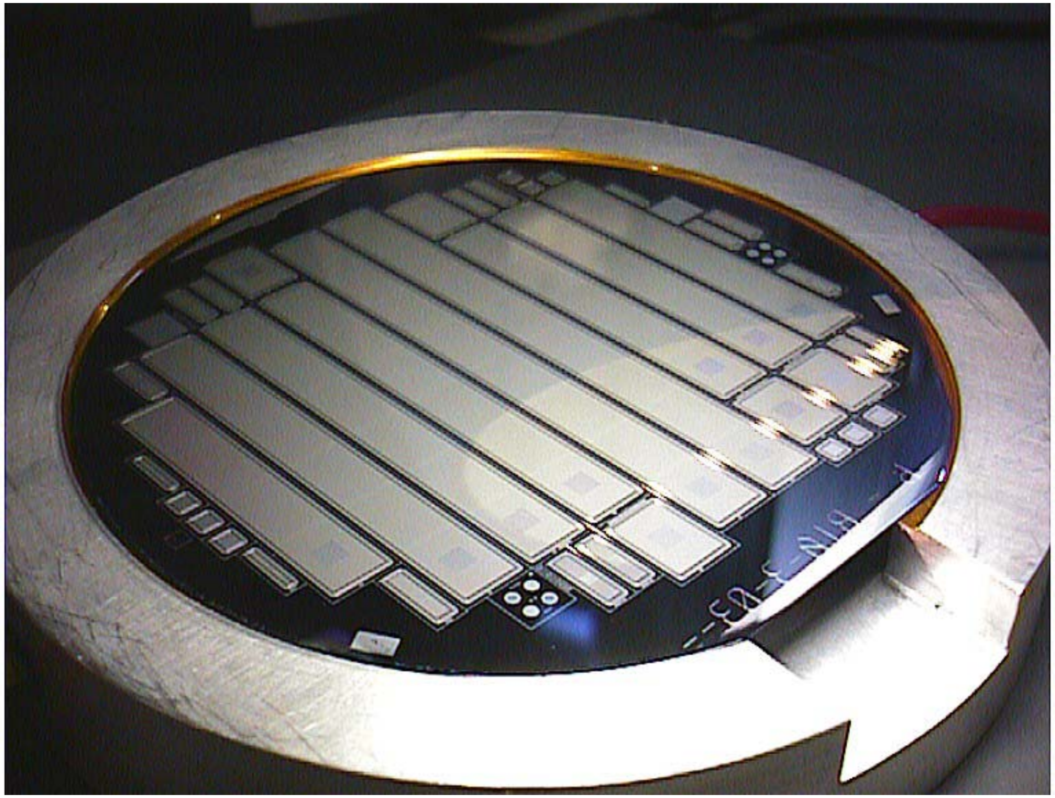
BTeV, ATLAS, & CMS

The BTeV pixel detector is very similar to the ATLAS (& CMS) detectors in some respects, and very different in others.

- Sensors
  - Early decision to use 50μx400μ pixels (same as ATLAS), so that we could use ATLAS sensors for R&D.
  - Very similar radiation tolerance requirement (near the beamline).
    - Baseline is "moderated p-spray" n-in-n sensors using the (patented) ATLAS design.
    - ATLAS & CMS results prove radiation tolerance.
- Bump Bonding
  - Same pitch as ATLAS pixels.
- Readout Electronics
  - 396ns (or 132ns) between crossings vs. 25ns @LHC means timewalk is much less of a concern.
    - No need to trim each pixel discriminator threshold.
  - Very high speed readout required to allow use of pixel data in lowest level trigger.
- Operation in Vacuum
  - Need to avoid liquid/vacuum joints makes cooling different.

Sensors

- Individual pixels are identical to ATLAS sensors.
- Number of rows & columns and overall size customized for BTeV.



Oxygenated p-spray sensors made By TESLA

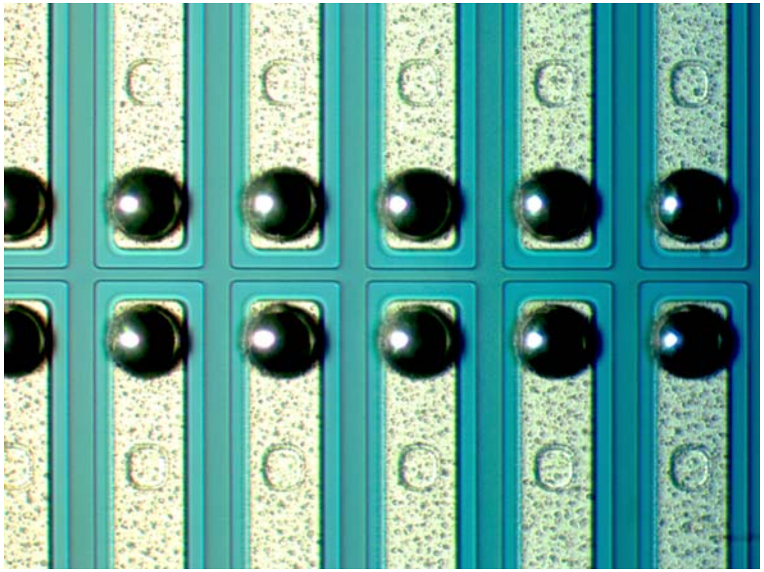
Each wafer contains:

- 1 “4-chip” module
- 3 “6-chip” modules
- 3 “5-chip” modules
- 2 “8-chip” modules
- These are the modules used in the baseline design; number on wafer chosen to reflect usage.
- 5 “1-chip” sensors

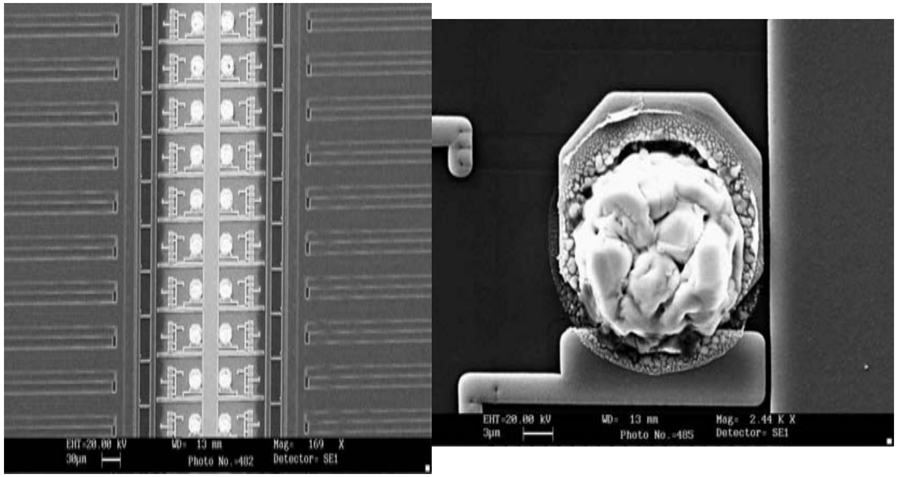
Bump Bonding

- Same pitch as ATLAS pixels.
- Modules are smaller.

VTT solder bumps

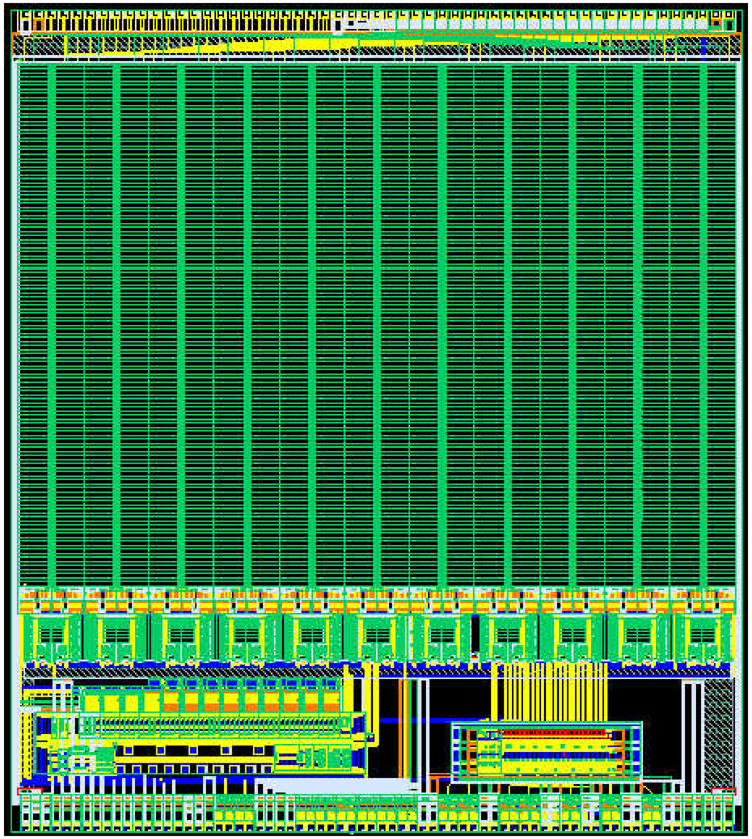


AIT indium bumps



Pixel Readout Chip – FPIX2

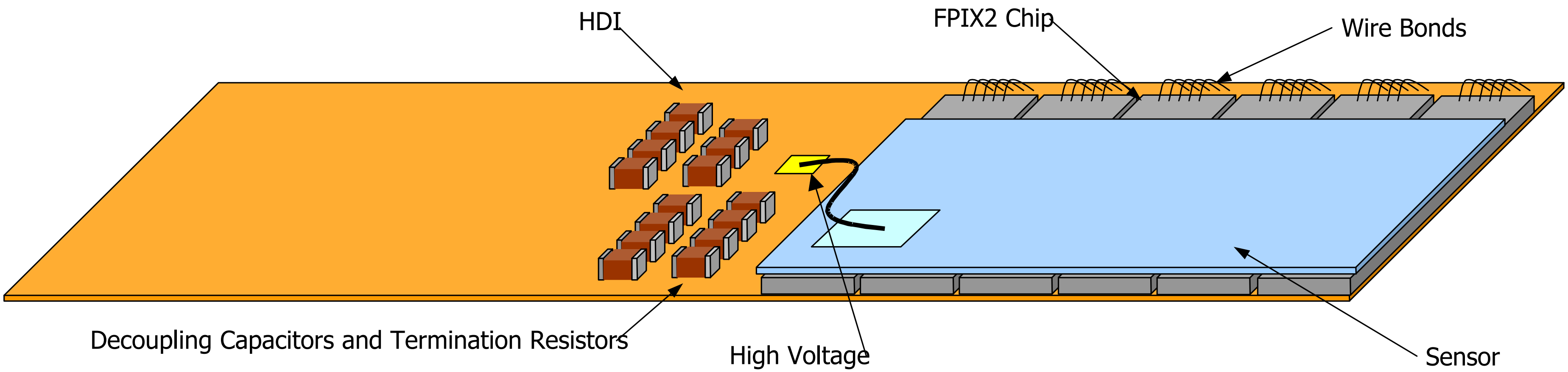
- Development of readout chip is essentially complete.
  - 0.25µ CMOS design has been verified radiation tolerant.
    - No degradation of analog performance after 87 Mrad.
    - Single event cross sections measured to be manageably small.
  - High speed readout implemented.
    - Data kept in pixels until it is transmitted off chip – no buffer memory.
    - Occupancy varies >x10 from point closest to the beam to edges furthest away.
    - Flexible serial data output interface allows the use of 1,2,4, or 6 (140 Mpbs) point-to-point LVDS (on copper)output links.

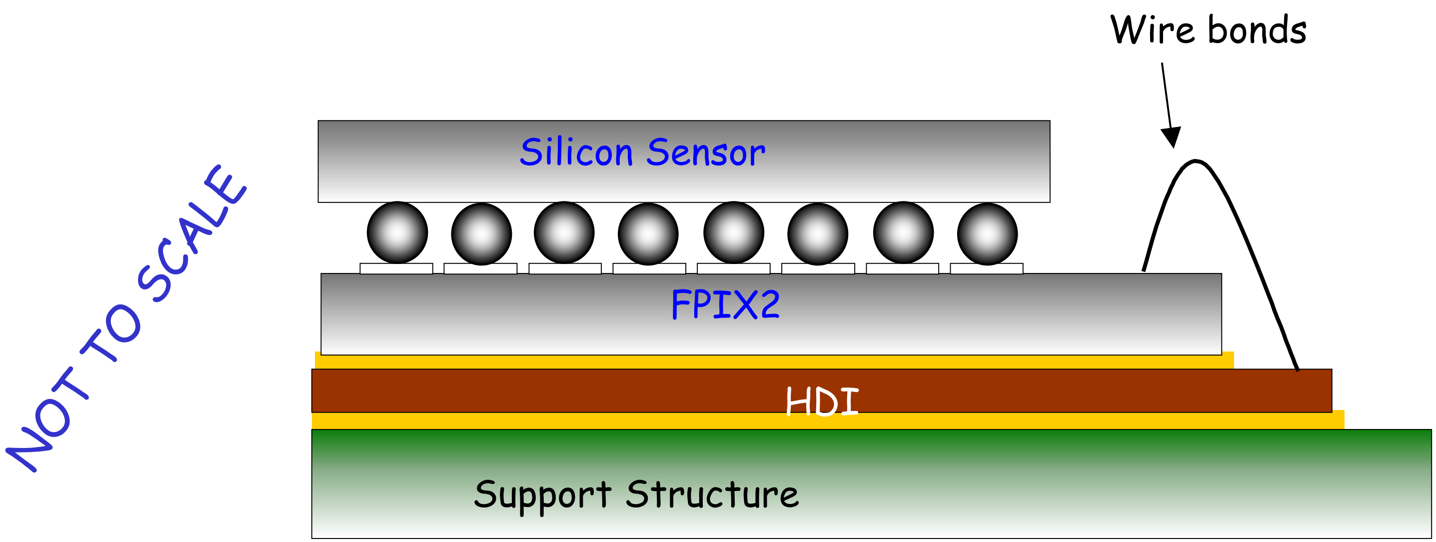


Operation in Tevatron Vacuum

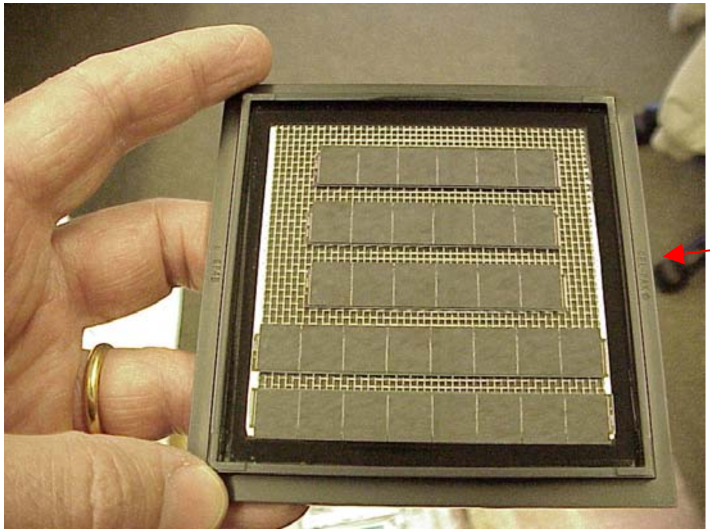
- Driven by desire to have sensors as close to the beams as possible.
- Vacuum is maintained by a system of cryogenic pumps.
- Detector is built in two pieces (vertical split).
  - Moved away from beamline during beam injection, acceleration, etc.
  - Moved close to the beamline once beams are stable at high energy.
  - Horizontal magnetic field means that (to first order) tracks do not cross from left to right.
- Each half of the detector is supported by a carbon fiber composite "half cylinder."
- Heat is carried away from the pixels by *conduction* in solid substrate (Thermal Pyrolytic Graphite) to liquid nitrogen heat sinks above and below the pixel stations.
- Pixels are separated from the beams only by a thin "RF shield."
  - Insures that microwave resonances are not excited in the vacuum box.

Cartoon of Pixel Module

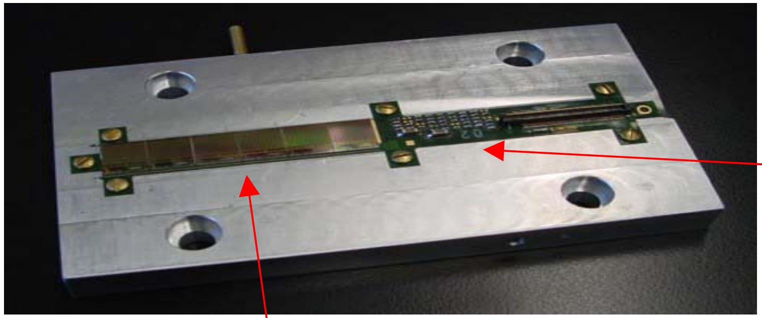




Prototype Pixel Modules



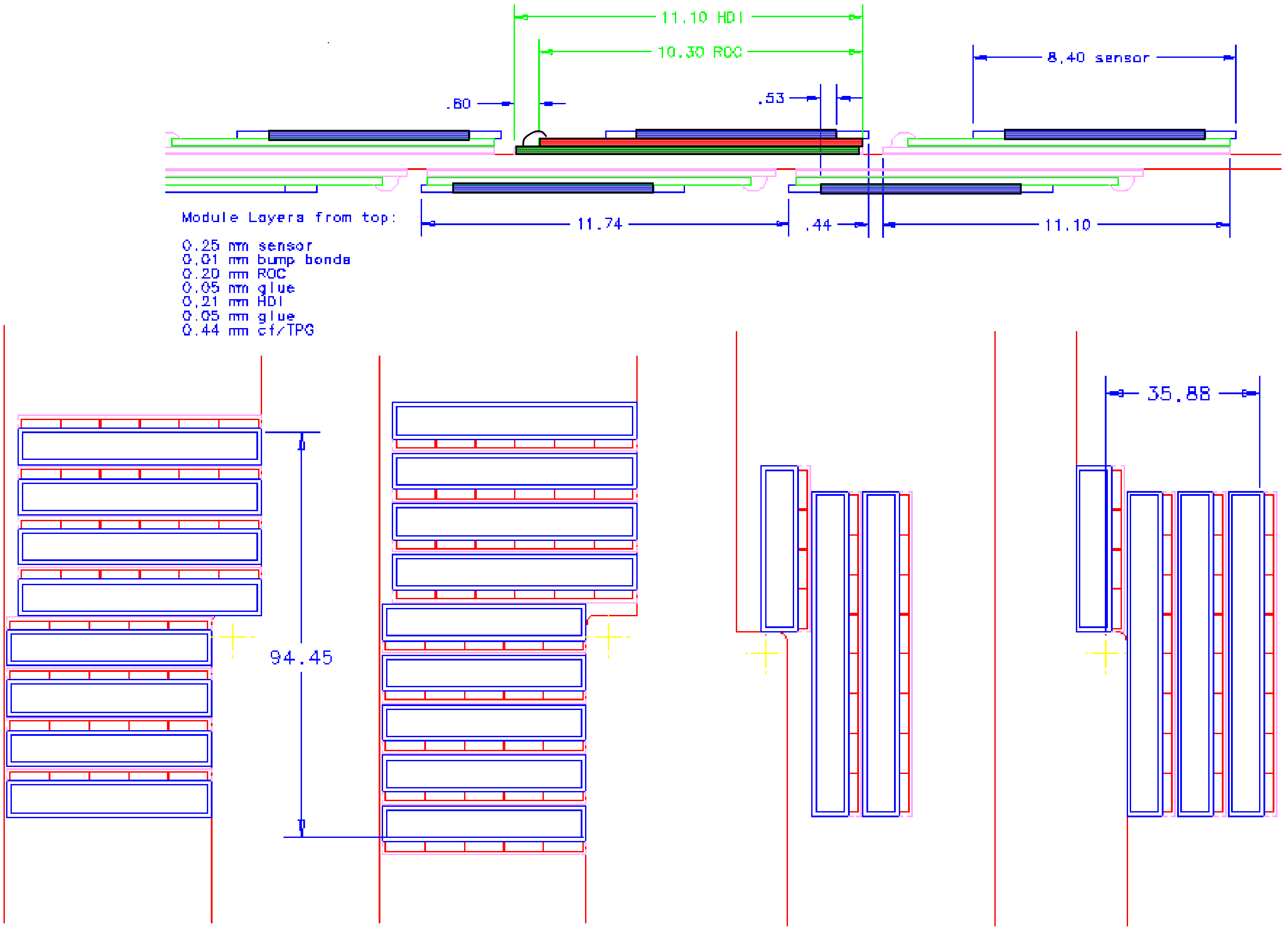
Hybrids recently received from VTT (TESLA p-spray sensors bonded to FPIX2 chips with solder bumps).



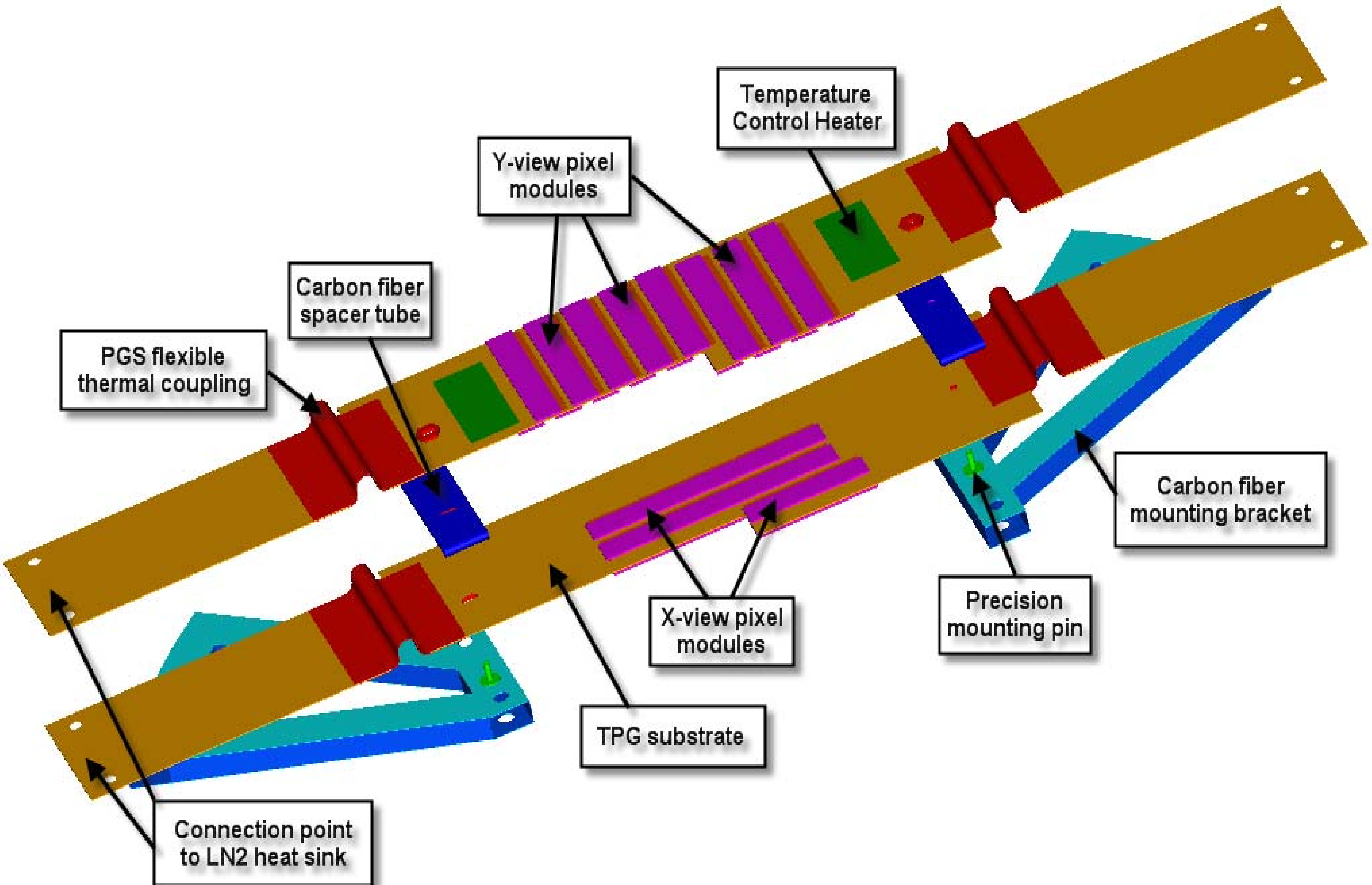
Prototype High Density Interconnect (HDI).

Six FPIX2 chips glued & wire bonded to HDI (no sensor yet).

Module Layout on Half Planes

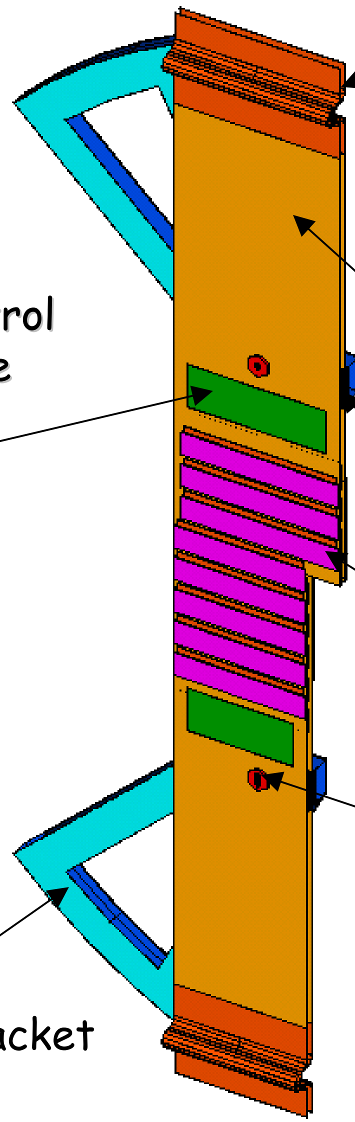


Pixel Half-Station

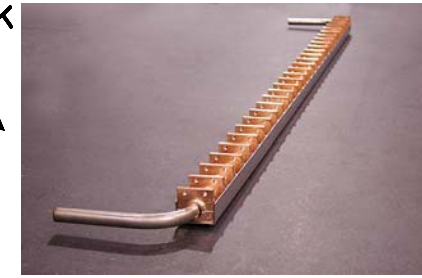


BTeV / Co

Pixel Half-Station (2 Half Planes)



PGS (Pyrolytic Graphite Sheet) flexible thermal coupling attached to copper tab LN2 heat sink



TPG (Thermal Pyrolytic Graphite)

The temperature control elements modulate the temperature of the substrate

Carbon fiber spacer

Pixel modules placed on both sides of the TPG substrate (active region: ~10 cm long)

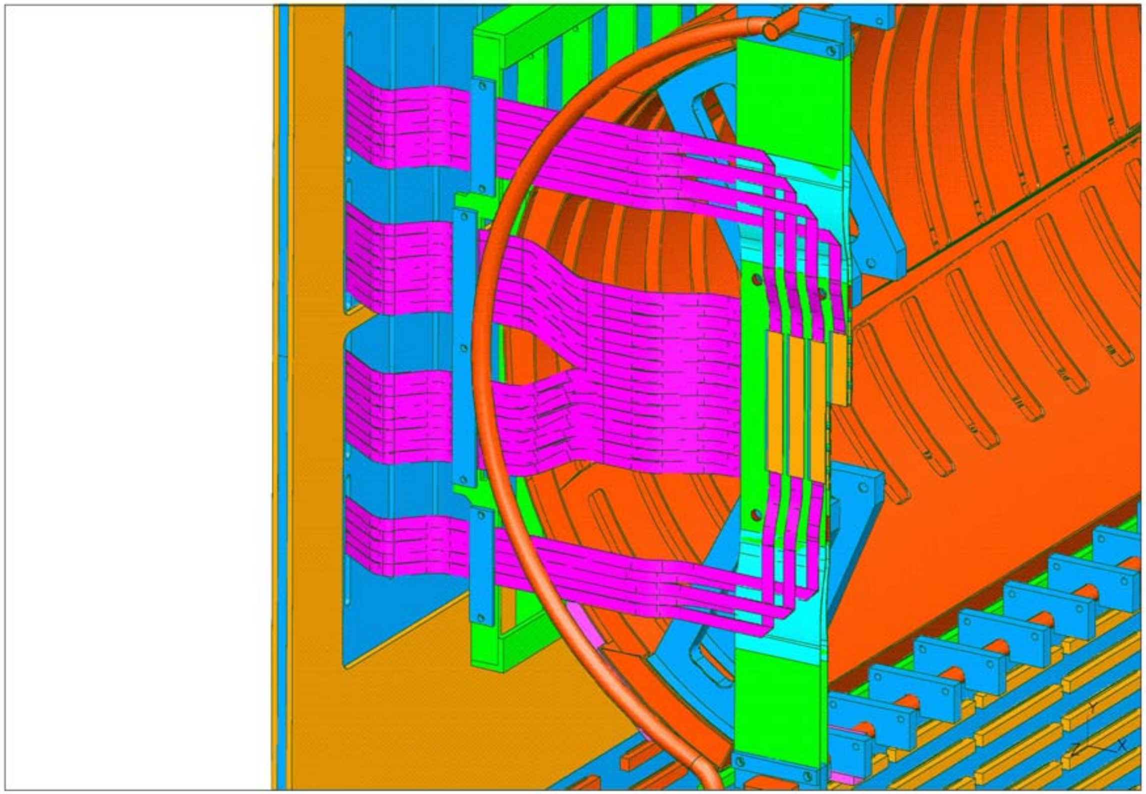
Precision hole & slot washers

Carbon fiber bracket

– TPG substrate is much simpler than previous fuzzy carbon design

Pixel Interconnect Flexible Cables (PIFC)

- Flex cables connect to Feed Through Board & then directly to the Data Combiner Board on standard data cables.



Pixel Detector Assembly